

# contributed articles

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**The benefits in school and the job market so far outweigh any potential gender bias that few women are deterred.**

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## Decoding Femininity in Computer Science in India

IN THE U.S., the share of bachelor's degrees awarded to women has declined by 10% since 2000; in 2011, women earned only 18% of bachelor's degrees awarded in CS.<sup>4</sup> It is thus no surprise that much research has focused on the underrepresentation of women in CS education, often portraying CS as a man's field.<sup>1,2,5</sup> However, this characterization is society-specific, not universal. Unlike in the U.S., women's participation in CS education in India has increased in the past 15 years in most nationally accredited institutes and universities;<sup>6–8</sup> for instance, women constituted 42% of undergraduate students in CS and computer engineering in 2011 in India.<sup>3</sup> They were and still are not the odd ones out, as the masculine perspective

might hold. Rather, they enroll in CS because men and women alike see CS as a woman-friendly field.

To understand why women in India are attracted to CS education, we carried out a qualitative study in 2007–2008, conducting in-depth interviews with 60 female undergraduates majoring in CS at two technical institutes and two universities granting four-year undergraduate degrees in CS. One campus is the top national technical institute, the other a well-known regional technical institute. To ensure minorities in India were included in the study, we included a third university that is historically Muslim and a fourth university that is predominantly Sikh. (Due to the University of New Mexico Institutional Review Board requirement that granted us permission to conduct interviews, we cannot disclose the names of the institutions.) We used random sampling to select 15 subjects at each. We recorded interviews that were transcribed and processed through the NVivo software package from QSR International for data analysis. Two independent coders coded the same data to ensure reliability. Here, we present key findings, along with frequency of response.

All students we interviewed were young unmarried women age 19 to 22 in their second-to-fourth year of CS studies. Other than being full-time students, none held a job at the time of the interview. A large majority of them characterized their family background as middle class or upper middle class. Almost 75% were born to Hindu families, with the majority from middle and

### » key insights

- CS is viewed as a liberating major and profession for and by women in India.
- Our study demonstrates how women's experience in CS differs according to sociocultural, economic, and historical context.
- It also outlines challenges women in India face to do well in CS education and seeking related employment.



high castes; remaining students were born to Sikh and Muslim families. They had attended private or central government schools that used English as a main medium of instruction.

#### **Early Exposure to Computers**

We asked whether they had a computer at home when growing up, and only a few (8%) reported they did. However, personal access to a computer was available to a little over half of them (53%) in their adolescent years. Parents typically brought home a com-

puter for work or for an older sibling. If not available at home, the students had access to computers in cyber cafés. A significant percentage (39%) had no personal access to a computer until enrolling in the CS degree program at a university or institute. Of those with personal access to a computer, most used it for non-technical purposes—to watch movies, listen to music, play games, browse the Web, or chat with friends or relatives.

We asked them to describe the computer resources available to them

in their high schools (ninth and 10<sup>th</sup> grades) and plus-two schools (11<sup>th</sup> and 12<sup>th</sup> grades). Whereas one-third (32%) reported having no computer resources in school, the rest (68%) said their schools had some type of computer facilities but with limited access. They also complained about high student-to-computer ratios, lack of useful software, limited access to computer labs, slow Internet access, and frequent electric power outages. Some reported learning basic computer skills and Microsoft Word in school.

### **Enrollment in CS**

As to how they became interested in pursuing a CS degree, they explained that as bright students, they were expected to choose between engineering and medical tracks after high school so picked the former. To be admitted to institutions of higher education in India, they had to sit for entrance and/or board exams; they chose their field of study based on ranks and/or marks they received in these exams. For over one-third (35%), a major motivation toward CS was family, directly or indirectly. Some (27%) said a CS degree offered promising career prospects, while others (18%) viewed computers as new social tools to help people. A few (15%) said they had developed their interest in computers as adolescents, without further specificity. The rest (5%) did not fit a category.

We also questioned them about the people who influenced their decision to study CS. A majority (62%) credited family members, not limited to, but mainly males, including fathers, brothers, cousins, and uncles. These men valued education immensely and saw CS as a proper field of study for women. The rest (38%) said either no one influenced them to opt for a CS major or were simply self-driven to pursue it.

**Educational background.** We asked whether their schools prepared them for undergraduate studies in CS. Over half (55%) said they were “not well prepared” because they did not have strong training in programming or CS in general. Over one-third (35%) felt “partially prepared” because they had taken basic computer classes. A few (10%) believed they were “fully prepared” because they were taught basic programming. Students in all three categories said their mathematics education was strong and thus helpful in engaging in CS at the undergraduate level. This was consistent with a majority of the students listing mathematics (77%) as their best subject in school, followed by science (20%) and computers (3%). Most said social studies and languages were their worst subjects.

### **Undergraduate CS Program**

When discussing their CS courses, a majority (60%) gave a mixed or nega-

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tive review; the rest (40%) responded positively. They said basic material was often omitted from course content, as it was assumed students had a basic level of proficiency in CS. This left many needing extra time with self-instruction to keep up. Overall, they said their courses were difficult but more rewarding than other courses in their institutions. They confronted this difficulty eagerly and embraced challenges. However, they did not enjoy the extra time required for class preparation and self-instruction; many also felt the material taught in the classroom was insufficient for homework and tests.

**Teachers.** The students reported favorably (51%), mixed (34%), and negatively (15%) when asked about their CS teachers. Overall, they said those teachers were knowledgeable, supportive, interactive, and motivating. Even demanding teachers with high expectations received praise or at least approval, as they were viewed as able to motivate their students to work hard outside of class. The students expressed aversion to teachers who came to class only to lecture and not care whether students understood the material. Other than the national technical institute, students from the other institutions expressed annoyance that teachers would often be replaced midway through a semester or that the teachers at their institution viewed the institution only as a stepping-stone to a better job elsewhere. Interestingly, none of the students mentioned the gender of the CS teachers, almost all of whom were men.

**Advisors.** Only students from the national technical institute reported academic advisors were part of their CS program. Some turned to their advisors for help choosing classes and schedules, though many found it helpful to discuss course choices with their senior and fellow students. Most students from other institutions reported relying on advice from peers and seniors. Some students at each institution claimed to be relatively self-reliant, choosing their courses independently.

**Peers.** A majority (63%) reported positively about their male and female peers, viewing them as friendly, helpful, intelligent, or even brilliant. Students discussed competition in a

positive light, explaining that the level of competition at their institutions was healthy and motivating. However, many (37%) gave somewhat mixed reviews of their peers, saying not all were good; some viewed themselves as technically superior to women and thus did not take women seriously when working on group projects. A few commented that the men were jealous of the women's presence in CS. Nonetheless, the students generally seemed to enjoy the presence of their classmates, getting along with them socially, as well as academically.

**Computer resources.** The students gave positive-to-mixed assessments of the computer resources available to them at their institutions, reporting facilities featuring specialties in Internet use and programming languages. Specific complaints were location-specific, centering on Internet speed and not enough computers. Such complaints typically came from the two universities.

**CS culture.** We asked the students to describe the typical perception of CS people at their institutions. An overwhelming percentage (90%) referred to CS people in a positive light, including highly regarded, respected, intelligent, smart, or extremely good within other technical disciplines. Some said the CS people love the minute details needed to make computer programs work. Only six students from the technical institutes used the term "geek" to describe a CS student. Interestingly, geeks were also perceived differently from the stereotypical U.S. view, citing creative or inventive and working hard at their computers to develop new and exciting programs and applications. There was general agreement among the students that CS people are social and enjoyable to be around.

### Gender and CS

As to whether careers with a CS degree are attractive to women, all students we interviewed agreed enthusiastically. Over half (54%) identified high-paying job opportunities with a CS degree, as employment can be found in multiple sectors, fields, and locations, including in global companies. Due to the tremendous ongoing growth in the IT sector, they said they would be able to take a job soon after graduation and

that IT jobs paid higher salaries compared to other fields. Another set of students (34%) emphasized the good work environment associated with CS jobs, viewing them as white-collar positions at a desk in a secure indoor office, possibly with air conditioning and coffee. They contrasted this with the work environment at a construction site or factory. They compared CS jobs with regular daily hours against the arbitrary hours and locations associated with medicine, a popular field considered by some in India as more suitable for women. Few (12%) cited social and psychological benefits, including independence by evading marriage plans set by parents, self-confidence due to regularly exercising their minds with critical analysis, and higher social status from the ability to perform technical work.

**Experience.** Questioned about how female students are perceived in the CS major, a large majority (88%) responded positively, expressing feelings of achievement and privilege from studying CS. They talked about the big compliments they got from family and friends for studying such a hot, exciting, challenging major like CS at a reputable institution. A few went so far as to say if they were in commerce, social studies, or medicine, they would not be treated with such respect. A small group (12%) expressed concern only because their male peers had better prior exposure to computers and continued access to support structures, thus making the CS program somewhat more challenging for female students.

Considering the U.S. perspective, where women are underrepresented in CS, we asked why so few women study CS at their institution. Some students (32%) said it was not true, seeing near-parity at their institutions or closing gender imbalance in CS. A majority (68%) depicted a gender gap that developed from a mixture of social biases and structural obstacles. Students from universities said many Indians typically imagine engineering as a male-oriented field and medicine, commerce, and social studies as feminine fields. They further blamed Indian society, which places women's first priority as marriage and raising a family, instead of pursuing an indepen-

dent career. Students from the technical institutes generally said women lacked financial resources for good coaching to do well on the entrance exams that would enable them to opt for a CS major.

**Obstacles.** Asked to describe the obstacles women face completing their degree, almost half (47%) said structural obstacles. Due to time curfews imposed on girls at their hostels (typically 8 P.M.), they could not stay in the labs longer and thus had more difficulty completing group projects and networking with peers. Those who lived at home had even more restrictive time curfews. During placement interviews, employers also questioned whether women had their parents' permission to work, as well as their marriage plans. Many students (36%) mentioned societal gender perceptions that identified engineering as a male-oriented subject, that women were not supposed to study beyond 12<sup>th</sup> grade, and that women's role was as wives and raising children at home. A few students (17%) explained that women are often forced to compromise within their families, setting their desires aside to go along with parental decisions and family harmony.

**Incidents.** To report specific incidents faced exclusively by women in a CS major at their institutions, a small minority (17%) had nothing to say. However, an overwhelming percentage (83%) reported a range of bias. One-quarter (26%) mentioned activities reflecting biased treatment from teachers, namely unequal expectations for male and female students and singling out female students for questioning or reprimand. One-fifth of the students (21%) described "gendered" restrictions, from curfews in the hostels where they lived to being excluded from male hostels, thus hindering spontaneous networking and group projects. Travel for possible internship, additional training, and job interviews were also a problem for some, as it is not socially acceptable for a woman to travel alone in India. Another set of bias cited by some students (18%) was specific to home and family, as they received less financial support and emotional encouragement than their male siblings for

higher education. A few (15%) reported teasing, both on and off campus.

**Confidence.** Asked to compare themselves academically with their male colleagues, they were almost equally divided between those (40%) who ranked themselves equal with their male peers and those (37%) who considered their male classmates better than them. Almost one-fourth (23%) said they were, in fact, superior to their male peers. Those who thought they were either better or at the same level were typically enrolled at technical institutes. There was general agreement that gender was not the deciding factor in determining who does well in CS courses. Rather, they said there are more opportunities available to men than women, causing some men to perform better; according to some of the students, if women had the same opportunities, they would do even better than men. Students from the predominantly Sikh university said women regularly received top grades. Lack of access to extra outside coaching, inability to stay late in labs and travel more freely, and limited computer exposure were some of the factors students cited as resulting in gender imbalance in CS.

**Attraction for men.** Asked what attracts men to CS, a large majority of the students (63%) said men were motivated to enter CS came from the pull factors characterizing the field. A CS graduate is able to get a well-paying job, which is a major concern for many men, especially considering they are viewed as family providers. Also, many job opportunities are available both inside and outside India. The rest (37%) identified such push factors as parents providing financial support for men to be in a potentially well-paid technical field. No one mentioned the geek CS culture as a compelling attraction for male students.

### Graduation and Future Prospects

Asked whether they had ever considered changing their major from CS to something else, an overwhelming percentage (90%) replied in the negative, showing considerable confidence in their decision to have selected CS as a major. It did not cross their minds to switch to another major due to the advantages, prospects,

or freedom they might gain from earning a CS degree. A small minority (10%) who considered other options did so only in the first year because they had no prior CS experience, thus making their coursework rather more difficult. However, by the second year these students were able to catch up and regain the confidence needed to complete a CS degree.

Asked whether they knew students who had switched majors from CS to another discipline, an overwhelming majority (81%) said they did not know others who had changed their major. They said the goal for many students was to be accepted into the CS program, so switching was held in low regard. Only some students (19%) from the two universities knew or had heard about someone who had dropped out to get married, join the Indian Air Force, or switch majors to electronics.

**After graduation.** After completing their CS degree, a majority of the students (65%) planned to take a job, mainly in the IT sector. Entering directly into the work force was appealing due to the opportunity so soon after graduation. Some said the additional flow of money from their jobs would ease their families' concern about the cost of their marriage. However, a few (13%) wanted to move directly into an MBA program or go on to graduate studies in CS. They viewed an MBA as providing them a broader range of employment options at an even higher pay scale than with a CS degree alone. The rest (22%) were undecided between pursuing a job or going further into higher education. They planned to make the final decision after evaluating their job placement options and possible admission to university graduate programs.

Asked to describe the most encouraging and most discouraging experience in their programs, they cited the success of their seniors and what their friends were doing after graduation. Most were inspired when students were able to find employment right after graduation from global companies. Some said they were motivated hearing about friends receiving summer internships at well-regarded companies. A few mentioned a peer's admission into a graduate program to study CS, as the popular trend was

to go for an MBA. On the other hand, many were discouraged by knowing someone unable to find a job after graduation. Some became dispirited over an overbearing workload. One-third of the interviewed students said nothing discouraged them or that since the CS program was the best, complaining was useless.

**Marriage.** With regard to the interviewed students' plans for marriage, a majority (63%) reported they planned to get married at some point. However, most had no desire to give up the hard-won independence they could expect with a CS job when married. A few also wanted to keep working after marriage but said the decision would have to be made jointly with their future husband and in-laws. Interestingly, a solid percentage (37%) said they were not contemplating marriage either at the time or in the future, wanting instead to work and travel, possibly abroad.

### Discussion: CS as Women Friendly

Since India's independence in 1947, Indian women, especially in urban areas, have gone to school and been educated in increasing numbers. However, the main purpose of them getting educated was typically not to prepare for a job, unless their families had a pressing financial need. Being educated was and still is considered a societal benefit, further making women "good" prospective brides and mothers. Indian women typically prefer career opportunities in government, teaching, and medicine. Engineering was and is still viewed as suited mostly for men, as is evident from the low enrollment and graduation figures of women in engineering programs in India. With the economic liberalization and reformist policies implemented by the Indian central government in 1991 and subsequent growth of the Indian IT sector, female students in India have come to view an IT career as appealing. This has led to increased enrollment of women in CS majors in Indian universities and technical institutes. As our study demonstrates, a CS major is perceived as women friendly, not only by female students but by their families in traditional Indian society. Students majoring in CS in general, and especially women, are viewed

as intelligent by family and friends, boosting their confidence to enroll in a CS major and stay with it until graduation. Majoring in CS is viewed as leading to well-paid employment opportunities in a range of companies in India, as well as abroad. Such employment typically comes with a high pay scale compared to other jobs. Moreover, they would be doing mental labor with leading-edge technology in a secure office as opposed to manual labor in factories and construction sites. With secure high-paying jobs, women are likely to have some social independence from wives and mothers in traditional roles. In this sense, female students view CS as a liberating major and profession, further questioning the assumption that CS is universally a masculine discipline.

Interesting complexities also arise due to the perceived role of women in a patriarchal society. Although a CS degree offers female students the ability to claim higher social status and become economically independent in the future, they still need their parents' approval before marriage, and husbands' and in-laws' after marriage, for pursuing internships, taking a job, and having a successful career. Even employers ask prospective female graduates whether they have permission from their parents to work, along with their marriage plans. Parents seem to be okay with their daughters pursuing a CS degree, as it goes well with their perception of the type of work their daughters would do, that is, mental work performed indoors at a desk, with minimal interaction with males.

The Indian female students majoring in CS we interviewed said problems in recruitment and retention of women in CS education is not due to the nature of the field but rather to the Indian patriarchal society and its value system favoring men. They did not characterize CS as a field for male geeks, which is demonstrably the case in the U.S., but for both men and women seeking high-paying jobs and aspiring to be competent computer and technology users. The word geek was rarely mentioned in more than 100 hours of in-depth interviews. Though fascinated by computer technology and consumed by

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figuring out its inner workings, the CS major is not seen as obsessive to the extent of being anti-social, a demonstrably widespread perception in the U.S. Both men and women seek to be computer savvy to get into a well-paid technical field by virtue of being smart and hard working. Even with the gendered treatment of female students and related social obstacles, those we interviewed never seemed to question whether a CS major is appropriate for them; on the contrary, they feel their standing in their families and in society as a whole is elevated since only smart students at the top of their class are able to major in CS. For those we interviewed, benefits of a CS career—high social status and independence due to a well-paid job—outweigh any bias from teachers and gender restrictions, even at institutions of higher education.

These findings are in sharp contrast with the reasons often given for low U.S. enrollment and graduation figures of women in CS degree programs. Most important, the U.S. image of CS as a man's field, even though many people in it view themselves differently; it has been suggested that this perception of CS leads to excluding women from CS.<sup>1,2,5</sup> However, our study shows Indian women have a very different story to tell, viewing CS as suited for all, especially women.

In the U.S., prior experience with computers is considered an important variable for generating interest in CS. However, few female students in India are regularly exposed to computers before enrolling in their institutions of higher education. They also found CS courses difficult initially, much like in the U.S. The reasons were different, however, due mainly to teachers not being considerate of lack of an adequate background of many Indian female students. Further, they could not work freely with male students on group projects since they had to return to hostels and homes to meet curfews. Despite such difficulties, these women have a strong desire to get a good job, so they continue to enroll and persist in CS because they view themselves as strong in mathematics and can learn on their own. Such perceptions give them confidence to pursue a CS major.

Another key issue helping explain CS being less attractive for female students in the U.S. is fewer female teachers in science and mathematics classes in schools, as well as a lack of female role models. These weaknesses are generally seen as reinforcing the attitude that these fields are not for women. Low numbers of female faculty in CS in U.S. universities is viewed as making many female students feel isolated.<sup>1,2,5</sup> Our study shows that for Indian female students, these were hardly issues, especially in contrast to other social factors. Indian female students rarely had female mathematics and science teachers in high school, and the number of female faculty in CS-related departments in Indian universities and institutions is even smaller than in the U.S. This is not to suggest that more female teachers in high schools teaching science and mathematics, as well as more women faculty in CS, would not help increase female enrollment. Rather, the Indian female students we interviewed complained of a lack of resources and opportunities they felt they must overcome to do well in CS in India.

These students belonged to India's middle and upper castes. While this might have given them an advantage over their peers in lower castes, male students in the same universities and institutes also tend to come from middle and upper castes. It would be difficult to argue that female students did thus not feel inferior to male students in their ability and intelligence, given that India is a far more male-dominated society than is the U.S.; they also did not feel superior to male students. Since caste is still an overriding factor in Indian society, a study of perceived intelligence based on caste versus gender is an important research direction worth pursuing.

### Conclusion

Our study shows that socioeconomic context must be taken into consideration to understand how gender interacts with CS education in India. Lack of interest by women in CS should not be viewed as a global phenomenon; women may not show interest in majoring in CS in the U.S. and perhaps other Western countries but definitely

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go for it in India. Among all engineering-related disciplines, CS is viewed as the most attractive to Indian female students. Further, CS is viewed as a major pursued by intelligent students, helping boost their confidence, especially among women; prospects of a high-paying job leading to independence from family and parents motivate female students in CS to do well and complete a degree, an academic pursuit where strong mathematical skills are helpful. This fact contradicts many conventional assumptions, including that CS is a man's discipline and CS reliance on mathematical skills might be a hindrance to attracting female students.

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